ISS Has an Attitude!

Determining ISS Attitude at the ISS Window Observational Research Facility (WORF) using Landmarks

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Outline

- Concept

- Secondary School Activities

- Higher Education Activities

ISS Has an Attitude!

- Universities and secondary schools can help solve a real issue for remote sensing from the ISS WORF through hands-on engineering and activities

- Remote sensing technology is providing scientists with higher resolution, higher sensitivity sensors.

- Where is it pointing? - To take full advantage of these improved sensors, space platforms must provide commensurate improvements in attitude determination

ISS Has an Attitude!

- Experiments in the WORF will rely on accurate WORF attitude knowledge to determine their own attitude, to know what is in their image

- Two choices for finding WORF attitude:
    1. Translate ISS navigation base attitude to the WORF
    2. Provide WORF with sensors to allow it to determine its own attitude through direct measurements.

- This project takes the 2nd approach

Concept

- A WORF sensor (e.g. camera) will accurately measure the pointing vectors (in the WORF reference frame) to surveyed landmarks on earth

- A large number of landmarks will be required in order to provide continuous WORF attitude knowledge

Three Phases of Project

1. **Proof of Concept**
   - Carry out the exercise with a few schools using visible landmarks on earth and existing cameras on the ISS

2. **Design & Development Phase**
   - Design and develop several sensor systems to solve the problem
   - Trade study to identify sensors that best solve the problem
   - Involve more schools

3. **Implementation Phase**
   - Systemize the process and export it to schools nationwide (ultimately worldwide)
   - Integrate the process into the ISS as a standard service

Secondary School Activities

- Participate in constructing and maintaining surveyed landmarks
  - Prototype schools may help in developing basic accompanying curriculum
  - Fold participation into classrooms by addressing math and science education content standards
  - Team with Universities for developing algorithms and WORF sensor

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Higher Education Activities

- Provide necessary algorithms to use landmarks for ISS attitude determination … develop them when necessary

- Partner with secondary schools to provide mentoring

- Conduct or assist with sensor trade study

- Develop feedback capability to participating ground stations for when their target is acquired

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Needed Studies, Algorithms (Examples)

- Reference frame definitions

- Determine Vector from WORF to landmark

- Relate Pixels in Image Plane to WORF Reference Frame

- WORF Attitude Tracking Filter

- Calibration Techniques

- Target Detection / Recognition

- Automation

Reference Frame Definitions

- Take existing defined WORF reference frames (define them if they don't exist) and relate them to existing defined ISS reference frames

- Study how well ISS attitude measured at the navigation base can be translated to the WORF

Determine Vector from WORF to Landmark

- Given the ISS position and a landmark's position, determine the pointing vector in a standard reference frame

- Relate this vector to the WORF reference frame

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Relate Pixels in Image Plane to WORF Reference Frame

- Each pixel in the sensor's image plane will correspond to a specific pointing vector in the WORF reference frame

- Develop algorithms to establish and calibrate this relationship

WORF Attitude Tracking Filter

- A Kalman filter will be needed to process the continuous input of new sensor data from the network of landmarks
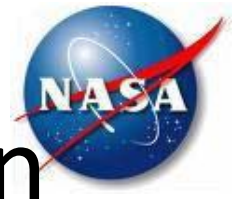
Calibration Techniques

- As system accuracy improves, calibration techniques will become more difficult

- Associated algorithm development will be needed

- Techniques and algorithms must be designed to work within the time constraints of the ISS crew or autonomously

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Target Detection / Recognition

- As the landmark network grows, the ability to detect and recognize targets will become critical

- Signal/image processing algorithms tailored to the selected sensors will need to be developed

Automation

- Techniques and algorithms will need to be optimized for automated operation as much as possible

OTHER IDEAS?